The TECH ENGINEERING NEWS

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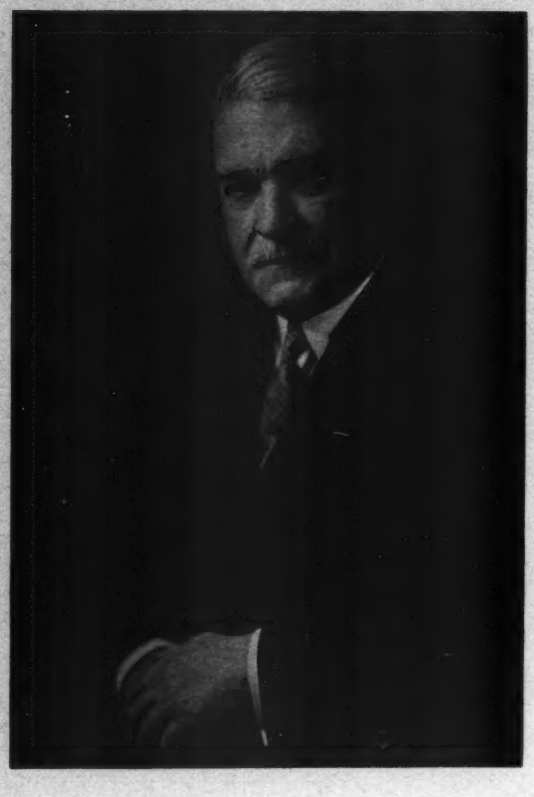


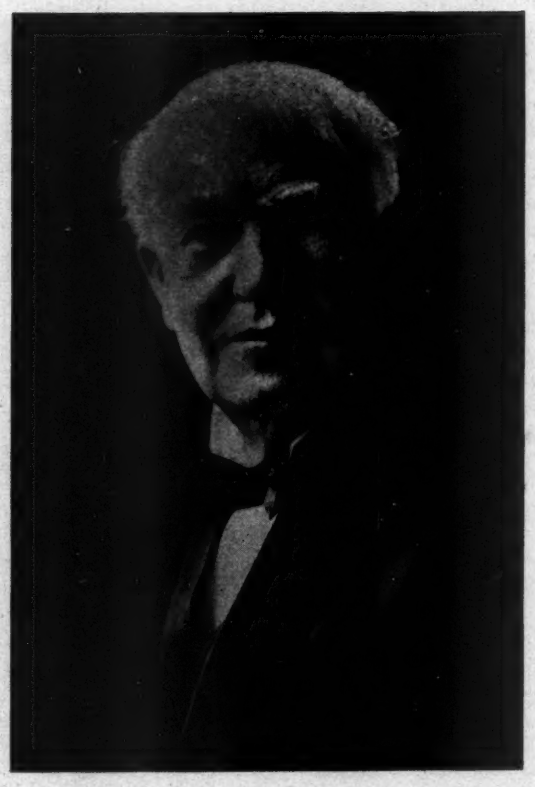
SAMUEL WESLEY STRATTON

"I DOUBT if any of us has ever known a man whose whole life has been so consistent, straightforward, and unswerving in its devotion to a particular form of public service. We mark today the passing of a great man. At the same time we recognize the lasting importance of those things which were the mainspring of his life, and we are happy that our position as his colleagues enables us to 'carry on'. . . ."

THOMAS ALVA EDISON

"THE death of Thomas A. Edison gives rise in my mind to this thought above all others,—that men of great achievement live forever . . . his genius in making science serve mankind has given birth to a new and progressive spirit of searching for improvements. The real significance of Edison's work is aptly described by a quotation from Pasteur: 'In our century science is the soul of the prosperity of nations and the living source of all progress'."....

Doctor Karl Taylor Compton



THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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ATOMIC THEORY—1931

BY DR. R. M. LANGER

Professor of Physics, University of Minnesota

SOME seven years ago I was present at a colloquium when a capable young Englishman reported on the newly published paper of Louis de Broglie, nephew of a leading physicist of France. There were prominent scientists present. At the end a lively discussion took place, but it was entirely one-sided. No one believed there was anything to it. "It was fantastic; you couldn't understand a word of it," said the man who reported the paper. I have heard that its reception was the same all over the world.

A few years later de Broglie received the Nobel Prize for that paper. Physicists, to a man, have adopted a new point of view. The unbelievable things in de Broglie's paper have become the obvious facts which beginners in advanced physics are expected to see at once. Even the undergraduate college texts are explaining the so called wave mechanics to students.

—*Scientific American*

A conventional model of the wave atom. Such graphical representations are losing favor with the physicist.

During the last seven years something startling has happened in physics. Physicists are startled by the new developments and also by the interest which outsiders have evinced in them.

It is the purpose of this article to attempt to explain these developments and to show their significance to the scientific world.

Let us begin with a consideration of the general nature of the situation. Physics is the most highly developed of the natural sciences. That is why the tremendous rearrangement of the last seven years occurred in physics. In the future the same sort of thing will reoccur in other fields as well. The phenomenon is this: a field is explored up to a point where progress becomes slow and difficult. Many workers are engaged with the particular problems which are proving difficult. More and more men are becoming familiar with the background of the subject and are acquiring a critical appreciation of the known material.

When a new idea is put forward this whole group is prepared to investigate its consequences and to modify it into its most favorable form. If the idea is an important one—that is, if it is capable of a large amount of development and extension—there follows a period of sudden progress. The whole subject is transformed. Only a small fraction of the workers are able to keep up with all the new developments. In a short time, however, the easier and more exciting problems are solved and then a period of gradual filling in and clarification begins. The new material is worked into a simple form and taught to beginners. Ideas which at first were too difficult for experienced men can later be assimilated by young students. This cycle is then repeated at intervals of varying duration. It is important to remark, and difficult to remember, that the periods of slow apparent progress are essential to the advance of a science.

We are concerned here only with the developments in atomic physics. The experiments and calculations which seem most important from our present point of view have as a group one outstanding feature. They show that one must be as *precise* as possible but no more *specific* than necessary. This apparent inconsistency may need explanation. For example: if an electron is accelerated by an electric field and drops through a measured potential difference, we had better be content with saying how much its kinetic energy has increased and not offer to specify its velocity until we are sure we need to know the velocity. I mention this simple case because it has caused an enormous amount of trouble for the physicist. He thought he knew the relation between velocity and energy. As a matter of fact that relation depends on just what sort of system the electron is, and this is unknown. But calculating the velocity incorrectly won't affect the experimental results. They depend only on energy. For this reason the physicist was fooled into thinking he knew much more about the electron than in reality he did. He was sure the electron was a little round particle. Such a prejudice made it very difficult to accept the experiments of Davisson and Germer on the wave-like reflection of electrons from crystals. A picture of the electron as a wave is suitable for these experiments to the same extent the particle picture is suitable for the experiments on the collisions of electrons with single atoms. But we might just as well put all pictures aside, and distrust the wave concept as well as the particle concept of the electron. Nowadays we simply ignore the distinction and thereby avoid many difficulties.

(*Continued on page 199*)

ENGINEERING THE FIRE ALARM

By Edward R. Schwarz '23

Professor in Charge—Fire Protection Engineering, Massachusetts Institute of Technology

Little thought is usually paid by the average citizen to the speed and certainty with which a fire alarm is transmitted, nor is much consideration given to the tremendous amount of time and effort which have been expended in the last three-quarters of a century on the development of fire alarm signalling along scientific lines.

A famous fire department axiom is that—"all fires are small when they start." Frequently it is only too true that 10 seconds saved at the beginning of a blaze is worth more than 10 hours after it is out of control. Hence, it would take but little exercise of the imagination to picture what conditions in any average American city would be if an alarm of fire depended for its transmission upon the lung power of the discoverer of the blaze. The present system, though, is new. It only just precedes the advent of the telephone and immediately follows the invention of the telegraph. It is well within the memory of living men.

Probably not since the dawn of history have the human voice and the spoken word been considered reliable as a fire alarm. Drums, horns, and bells were early used, and are not yet eliminated from the picture. In 1658, in New Amsterdam, sixteen watchmen patrolled the town with watchman's rattles which they used vigorously if a fire was discovered. Even today certain Swedish fire alarm boxes contain, not clockwork and telegraph key, but a horn which must be blown by the citizen. In many rural communities, fire alarms were sounded by means of lusty blows of a sledge against an iron cartwheel tire. This method is in use today in a town only a few hundred miles from New York City.

In Boston, Dr. W. F. Channing recognized the importance of Professor Morse's invention of the electric telegraph as a means for the efficient transmission of fire alarms, and in an article published in the *Boston Advertiser* in 1845, described his idea of such a system. While nearly eighty years of engineering work and scientific research have developed it until a high state of perfection has resulted, the modern system has in itself the important features of Dr. Channing's plan. His system involved separately numbered stations on the streets and mechanical means for striking signals on tower bells. The first alarm in Boston was transmitted over the system installed under Dr. Channing's direction on April 29, 1852.

The first alarm box contained a switch and a telegraph key. After opening the circuit by throwing the switch, the signal was transmitted manually. On the modern box the instructions simply read—"Pull the hook once." On the original system, the instructions were printed and placed on the inside of the door.

It was soon apparent that aside from the delay due to reading the instructions, there were other serious disadvantages. The fact that the circuit was open during the transmission of the alarm, and had to be closed manually, made the system difficult to supervise. Finally, to avoid difficulties in the manual operation of the key, a toothed wheel was substituted, and a crank was attached to it so that rotation of the wheel made and broke the circuit according to the number and spacing of the teeth. The directions were simplified to read—"turn the crank 6 times slowly."

Now nobody—such is human nature—heeded this last qualifying adverb, particularly in the excitement of an actual fire, and the crank was in most cases turned so rapidly that the signal became only a rattle. Engineering came to the rescue immediately, and the crank was removed from the code wheel and so placed as to actuate a train of gears. New directions requested the operator to "turn the crank 26 times slowly." Apparently, even in Boston, few people could count to 26 correctly, and still fewer heeded the warning to turn the handle slowly.

It was quickly apparent that the use of a closed circuit which could be intermittently opened at the desired interval spacing was correct both in theory and in practice. A code wheel seemed to work well, if its speed of rotation could be limited and held constant. Again the engineer stepped in with a weight actuated gear train. When a trigger was tripped, the descending weight actuated the gear train, and the slow and uniform rotation of the code wheel transmitted several rounds of the alarm. The weight was cumbersome, and the effect of weather, birds, insects, etc. . . . was to cause interference with the free action of the system. Enclosed, spring-driven clockwork is used for the necessary power in the modern box.

With the enlarging of systems to care for the rapid growth and increasing congestion of cities, the problem of simultaneous operation of several boxes became important.

Non-interfering type boxes were the result. They may be of two kinds. First are the *partially* non-interfering, which are again of either of two forms. In one the circuit is so manipulated, when the box goes into action, as to shunt out the entire circuit on the side away from the battery. This, of course, eliminates the possibility of any signals from a box in the shunted circuit being transmitted. This condition involves delay which it is the object of the whole system to minimize to as great a degree as possible. There is another feature which is undesirable. A box which is between the first one sounded and the battery may be pulled for the same or another fire. In this case the new box takes control of the circuit as soon as sounded, shunts out the earlier one, and proceeds to transmit its own signal. Eventually the box nearest the battery gets in a complete round. Here again delay is inevitable. The uncertainty introduced because of the failure of the box to control the alarm system directly is hazardous.

In the other method, the alternating, one box takes the circuit from another at intervals; but only at the beginning of a round. If box 37 is sounded just after box 62, the alarm may be received (62-37-37-62), (62-37-62-37), (62-62-37-62), etc. . . . But by the time that the department has made sure what the separate boxes are, and have checked each, many valuable seconds have been lost.

—Gamewell Co.

The first Fire Alarm Headquarters of the City of Boston, established in 1852.

The second scheme is to provide *totally* non-interfering boxes. Here one box takes control of the circuit and holds it to the exclusion of all others. It will transmit its own signal for the full number of rounds required, and then will restore the circuit to normal. Any other box or boxes which may have been pulled during the transmission of the first box's signal will not signal at all and will have to be pulled again.

It took 30 years of intensive engineering to develop the non-interfering box. It required 10 years more of constant development and exhaustive testing to perfect the so-called "successive" type, which is non-interfering, but in addition, allows other boxes, after a predetermined number of rounds, to successively take control of the circuit and to transmit a definite number of rounds in turn.

The newest successive box is arranged to transmit the alarm and to retain its successive features to a surprisingly complete degree, even when the circuit is actually out of order because of short circuit or broken wire. Each box is independently grounded, and when notice of the opening of the circuit—from whatever cause—is given to fire alarm headquarters by the sounding of a single stroke, a simple adustment of a switch by the fire alarm dispatcher allows the boxes on the circuit to perfectly transmit over the ground circuit.

With the increasingly widespread use of the telephone, it might seem that this device could be made to serve instead of the more elaborate equipment housed in the fire alarm box. Such schemes have been experimented with both here and abroad.

The telephone promises to serve an important part in the solving of the fire alarm problem, if indirectly. The success and growing reliability of the dial or automatic machine switching systems have placed in the hands of the fire alarm engineer a very interesting mass of equipment and methods. Already numerous large industrial plants have adopted fire alarm systems using such apparatus throughout, and the design of municipal layouts is already a fact.

The system is a line-per-box circuit, but certain features of it make it possible to wire the circuits at little if any greater expense than for the older loop systems. There can be no interference of boxes on the same loop, therefore. Further, there is no coding mechanism in the box itself. The box contains essentially a reliable relay. There are no springs to wind, and no gears, or other moving parts of like nature. The circuits are closed and therefore can be supervised continuously. Alarms are sent by merely pulling a lever, which operates the equipment in the engine houses and in the central office, causing an audible alarm to be sounded, and lighting a lamp individual to the line. Punch registers and such public alarm devices as may be desired can be operated.

Radio is also coming into use for fire alarm work. Several cities—including Boston—have facilities for this work. In the latter city, for example, there is constant two-way communication whenever desired between the fire alarm headquarters and the fire boats—wherever these may be. Since the dispatcher is in constant telegraphic communication with the chief's driver from the nearest box to the fire, orders originating with the chief can be very quickly transmitted to the fireboats which may be out of sight and sound of the landward side of the blaze. This feature is invaluable for efficient fighting of waterfront fires. It is possible that the system may also be eventually extended to include the chief's cars. Thus they may be in communication with headquarters at least for reception of communications wherever they may be.

The city of Quincy, Massachusetts, has just established teletype communication with all its apparatus houses for the transmission of still alarms. This is the first complete installation in New England and marks another step in the progress of signalling for fire departments.

(*Continued on page 200*)

—Gamewell Co.

The present Boston Fire Alarm Headquarters. Contrast the present methods with those in use 79 years ago, shown above.

THE PHOTOELECTRIC CELL INTEGRAPH

PHOTO-ELECTRIC cells are now playing a part in the general scheme of computing device development in progress at the Massachusetts Institute of Technology. A new integraph perfected by Dr. Truman S. Gray, with Professor Vannevar Bush of the Department of Electrical Engineering, utilizes such cells and extends the usefulness of machine processes for the solution of complicated problems to the evaluation of integrals having a variable parameter within the integral. Among these are such often recurring integrals as the Fourier transform, the superposition theorem, and integral equations of the closed cycle.

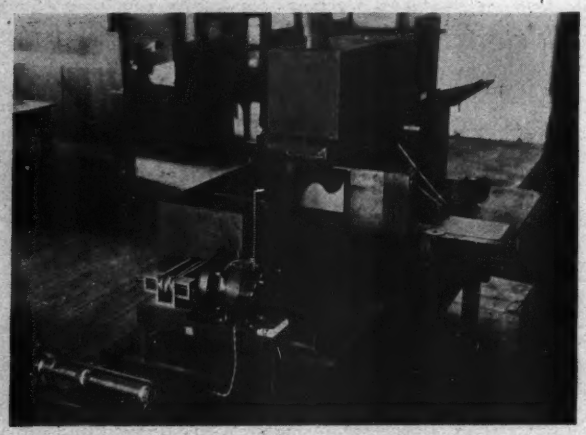
THIS article was written by a member of the editorial board of TECH ENGINEERING NEWS from information supplied by Dr. T. S. Gray, of the Electrical Engineering Department, who developed the instrument. It is an attempt to explain the principle of the newest aid in solving complex mathematical problems. The manuscript has been read by Dr. Gray, and it is published with his authorization.—Editor.

Recently this device has been used to analyze the flow of the Ohio River, which required the solution of a problem of periodogram analyses. The results obtained checked with reasonable accuracy the actual observations taken on the river over a period of fifty years and are valuable in that they may be extended into the future.

It is also particularly useful for the study of transients in electrical circuits and in statistical correlations.

Principles and Description of Machine

The principle of the machine is based upon a suggestion of Dr. Norbert Wiener that an integrating device of this nature could be made which would use light passing through apertures whose shapes would represent graphically the functions to be multiplied and integrated.



The Photoelectric Integraph, developed by Dr. Truman S. Gray of the Institute, solves intricate problems by the modulation of a beam of light. A photoelectric cell interprets the results.

Briefly, two beams of light are used, one from a line source being passed successively through apertures in two masks and then converged into a photo-electric cell. The second beam passes into a second cell through an auxiliary system which keeps its intensity equal to the intensity of the first. The first beam is measured by keeping both cells balanced and these measurements are plotted as a continuous result curve on a result platen during the operation of the machine. The condition of balance between the cells indicates that the result is being plotted properly.

To build a machine operating under these principles, it was necessary, first of all, to devise a light source. Since it is very difficult to obtain an actual line source of light of the required length and uniform brightness, a virtual image was adopted instead. A mirror is oscillated through a small angle with a uniform angular velocity and reflects the image of an actual light source consisting of a 200 watt incandescent lamp located in a metal cylinder having appropriate windows.

A crank mechanism oscillates the mirror in such a way that the light from the virtual image produced by it is thrown on the masks only when the angular velocity of the mirror is practically constant. Thus the average intensity over the whole length of the mirror is uniform. The first mask is held in front of the face of the mirror in grooves while the second mask and result platen both move on one carriage, located twice as far from the light source as the first mask. The scale of this second mask is twice that of the first, for this reason.

Light passed through the two apertures is converged by a large lens system into an integrating sphere surfaced on the inside with magnesium oxide. This sphere diffuses the light and eliminates the directional effect of the main photo-electric cell which is more responsive in some directions than in others. Use of the sphere brings its response to well within the desired limits of accuracy which are from two to five per cent.

The balancing auxiliary light beam comes from the same source as that for the virtual image. It is directed upward, reflected horizontally by a mirror, converged by a lens, passed successively through a sheet of plane glass and a piece of ground glass, and reflected by a mirror downward through a shutter where it is finally directed by a second lens into a second photo-electric cell located in a shielded box.

Both glass plates are used to vary the maximum amount of light passing through the auxiliary light system, thereby adjusting the scale of the result curve to be drawn. Diaphragms placed on the face of the

(Continued on page 198)

THE TRANSATLANTIC LINER–1819-1931

By Robert H. Macy '33

The design and construction of an ocean liner is a problem of considerable magnitude, for the maximum speed, comfort, capacity, and safety must be obtained with a minimum of weight, power, and cost. These ships, although sometimes a fifth of a mile long and weighing eighty thousand tons, are designed with such trim and symmetrical lines that one does not conceive of them as enormous structures, but as things of beauty and grace.

It was emigration from the Old World to the New, starting after the War of 1812, that led to the development of the transatlantic liner. In 1819 the first steamship crossed the Atlantic, carrying with it a book published by a professor in which he proved conclusively that it was impossible for a steamship to cross the Atlantic. This was the *Savannah*, which went from Savannah, Georgia, to Liverpool in thirty-five days at an average speed of five miles per hour under combined sail and steam power, using wood as fuel. In spite of her successful trip across the Atlantic, her engines were removed, and she was operated as a sailing vessel until wrecked in 1822.

One of the best known of the early transatlantic steamships was the *Britannia*, built in 1840, a 1154 ton side wheeler 207 feet long, equipped with sails, the steam engine not then being considered sufficiently reliable to constitute the sole means of propulsion. The *Britannia*, with three similar boats, operated a fairly regular mail, cargo, and passenger service between Liverpool and Boston. The success of these vessels demonstrated that steam had come to stay, and a number of transatlantic lines were organized employing vessels of gradually increasing size, speed, and reliability.

It was in 1870 that the transatlantic liner began to appear in its modern form. A typical ship of this period was the *Oceanic*, 420 feet long with a capacity of 3601 tons. She was the pioneer in the luxury which has made ocean travel so popular, and was a departure from conventional design. The old bowsprit and sail yards, relics of the days of auxiliary sail power, were abandoned, deck houses were extended to the full width of the vessel, and staterooms were made light and airy.

In early years, the speed record for transatlantic passages was held by the British, although the French and Germans had ships which were nearly as fast as those of the British. The Germans made no attempt to capture the "blue ribbon," for so long as they were carrying the bulk of the trade, and making the most money, they were content to let the British have the speed record. Competition became so keen, however, that the Germans were led to secure the "blue ribbon" of the Atlantic in 1897 by the 23.5 knot liners *Kaiser Wilhelm der Grosse*, *Deutschland*, *Kronprinz Wilhelm*, *Kaiser Wilhelm II*, and *Kronprinzen Cecilie*. This group of vessels was supreme in speed for ten years.

The British steamship operators found the speed race highly expensive, and abandoned it for a time, building a series of large size, moderate speed liners, which were well received by the public. These ships, built between 1901 and 1909, were 16 to 19 knot liners of 20,000 to 25,000 tons, and most of them are still in service.

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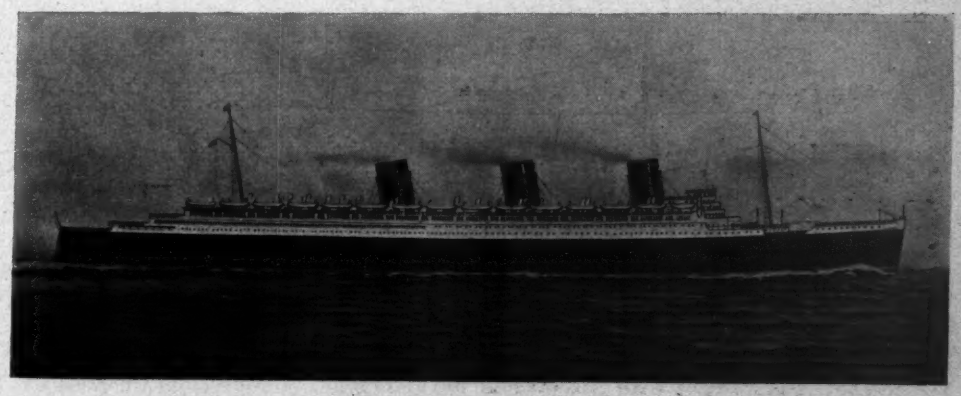
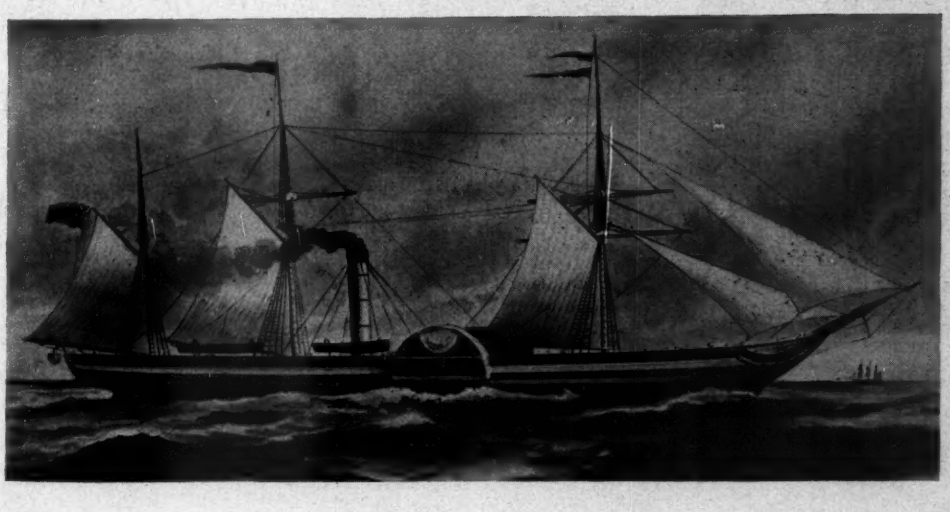


The "Princess Elizabeth" which upon its completion in 1933 will be the largest ship afloat. Length 1018 feet, width 115 feet, 73,000 gross tons.



The "Britannia," one of the best known steamships of its time, built in 1840. Using both sail and steam, it operated on the first schedule between Liverpool and Boston.

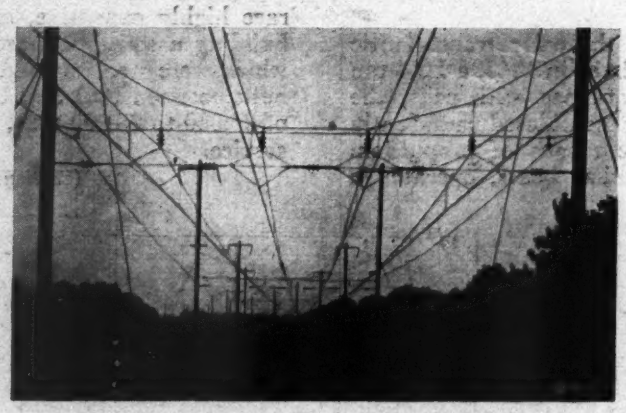
COPPER IN THE IRON HORSE

By J. V. B. Duer

Electrical Engineer in Charge, Pennsylvania Railroad

Electric operation of trains has progressed through several definite stages. Prior to 1915 it was accomplished by the use of direct current from third rail. This type of installation is in operation on portions of the West Jersey & Seashore Railroad, the Long Island Railroad, and in the Pennsylvania Station in New York; but in 1908 extensive tests which were made of the single-phase 11,000 volt system indicated its suitability for use on the Pennsylvania and in 1915 an installation of this type of electrification was placed in service at Philadelphia. The construction and operation of this electrification from Philadelphia to Paoli, a distance of about 20 route miles, resulted in further suburban electrification until in 1930 all suburban trains operating out of Philadelphia had been electrified with the single-phase 11,000 volt system.

Late in the year 1929 construction work was started for the electrification of the suburban trains between New York and New Brunswick including the electrification of a large storage yard at Sunnyside, L. I. This work is now nearing completion and early this year a program was announced by President Atterbury in which the electrification between New York and Washington for passenger and freight trains would be completed in the course of the next two and a half years.



Typical catenary tangent construction in railway electrification. Notice the insulators between each line.

As may readily be imagined a project of this magnitude in order to be successfully carried out necessitates that the various phases of the work be carefully considered. The design of the electrical equipment must be such as to not only assure that it is abreast with the present development of the art but that it may be as readily adapted as possible to future developments.

It may, therefore, be interesting to recapitulate here certain points which have been mentioned in previous articles as requiring careful consideration, both in the selection of electrical equipment and circuits as well as in the application of this apparatus and these circuits to a section of railroad which it has been decided to electrify. This question naturally divides itself into three general headings:

1. The electrical apparatus and circuits to be applied to the railroad.
2. The application of this equipment to the railroad and the modifications in the existing railroad equipment to be made at the time of the application.
3. The selection of the motive power equipment necessary to operate the trains electrically after the installation is complete.

Taking these questions in their order and referring specifically to the Pennsylvania Railroad electrification, it may be pointed out that when the first single-phase electrification was applied to our railroad in 1915 the equipment and the arrangement of circuits selected was of the most advanced design available at that time. Through electrification, open air sub-stations, 132,000 volt transmission circuits, quick acting trolley circuit breakers, both of the oil and air break design are being used, which reduce maintenance costs and increase reliability and capacity, but which were not available at the time the first electrifications were installed.

In electric locomotives and multiple unit car design, the progress of the art in single-phase motor design in recent years, as well as experience with various experimental locomotives, which have been built from time to time, have permitted standardization of car and locomotive equipment to a far greater extent and in capacities and types of equipment which were not available when the initial electrification was made in 1915. Experience in the design of electric locomotive and car equipment has permitted in the most recent designs the use of various details such as anti-friction bearings in the journals, which will, it is believed, materially reduce the maintenance costs and in addition, by so doing, will greatly assist in securing that increased use of equipment which is one of the fundamental developments secured by electric operation.

Taking now the second important item, namely that of applying the equipment and circuits to the railroad, certain outstanding questions necessarily have to be considered. In the first place, a careful survey of electrified territory was made with the idea of locating sub-stations and catenary structures in such a way as to meet the requirements of the present physical layout of the railroad, and for physical requirements of the railroad which might be foreseen over a reasonable period of time, and the necessities of voltage regulation, ease of control and property available. As an example of these requirements it might be pointed out that in locating a substation it not only had to be located so that it met requirements of voltage regulation, proximity to a point of control such as an interlocking, and property available; but it also had to meet the possibility of future elimination of the interlocking at which it was placed, readjustment of the control to some other point, if necessary, and the possibility of extension to meet the increased loads which would be imposed by expected growth of traffic.

(*Continued on page 197*)

ENGINEERING DIGEST

Condensations of outstanding articles in the leading trade and scientific journals, published by special permission.

What Do Engineers Earn?

Condensed from Power, issue of September 1, 1931

Last year, the American Society of Mechanical Engineers appointed a committee of nine prominent engineers to gather the facts about the earnings of the engineering profession. To each A. S. M. E. member was sent a questionnaire asking the desired information, both as to his earnings, and his education, job, etc. More than 50% of the membership responded, and facts were turned over to statistical experts in Yale University.

They based their report on the earnings of the median, not average, engineer. The median has as many men earning more than he as there are earning less, and is considered to be a truer indication that the average, since he is in the middle of the group and therefore typical of it.

This typical engineer reaches a maximum in his earning power between the ages of 53 and 58 years of age. At that time he is earning $7,500 a year. Earlier in life, his earnings have grown from a starting salary of about $2,000 annually. As the committee reports it: "He (the median engineer) has about $2,700 to marry on, $3,500 after his second child is born, $6,500 when his children are in high school, $7,000 when they are in college, and $7,500 when they are self-supporting. After 63 he must look forward to an earning power declining to $6,800 a year."

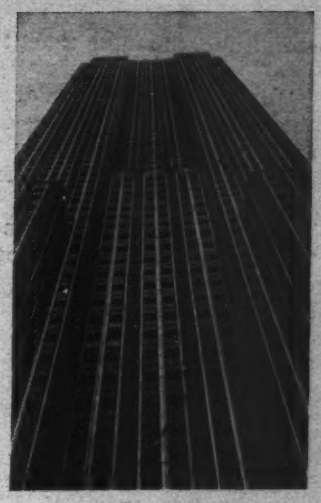
The survey showed a considerable difference in earnings in different geographical districts. Around New York City, the median reached a maximum of $10,000 a year; in New England, $7,200; and in the south, west and prairie states, about $6,000.

The statistics indicate that after 55 years of age, men with graduate training earn less than the men with standard engineering-school training. This is explained by the fact that the former tend to stay in strictly research positions and do not become general executives.

Difference in earnings was marked according to the type of occupation. General management attained a maximum of $12,000 a year, consulting work about $9,000, buying and selling about $6,750, while technical operating, designing and academic work averaged generally less than $6,000 a year, maximum.

It was found that managerial ability pays better than technical skill. The reputed high earnings in salesmanship were considerably less than those of men in general management positions. The earnings of teachers compare favorably with those in the technical branches of engineering.

The Committee concluded: "Regardless of whether the grouping is by type of technical functions, or by managerial and non-managerial responsibilities, the difference between managerial and consulting earnings, and all others, is so great as to suggest the importance to young men well trained in engineering of seeking to add to their engineering ability some capacity for dealing with people, or for managing organizations or businesses."



The Perspective of Modern Physics

By Paul R. Heyl, *Physicist Bureau of Standards*

Condensed from the Scientific American, September, 1931

What natural causes are there which may act as a brake on too rapid scientific discovery? The necessity of some such arresting force was suggested by the Bishop of Ripon some years ago when he suggested a scientific holiday. It is certainly true that the vast accumulation of fact and theory, especially in the field of physics, has made it difficult for all but a few leaders to keep pace. This situation, like a commercial boom, cannot last forever. Sooner or later natural forces will arrest the progress of further inquiry until facilities, both mental and otherwise, have been provided for its use. Undigested fact and theory is a drag upon progress; eventually the pace must be reduced to that at which assimilation can take place.

Even now there is evidence that the slowing-down process has begun. Scientific activity has not diminished; rather the contrary is true. But the nature of the present most advanced theories gives evidence of a natural impasse. It appears that certain types of knowledge are gained only at the expense of other knowledge. In an effort to ascertain the reality of matter, physicists have removed the electron and the atom to a shadow world which has no counterpart in reality. De Broglie and Schrödinger tell us that atoms are little bunches of vibration in something, the nature of which is not quite clear. What was once (at the time of the Bohr-Langmiur theory) a miniature solar system is now an intangible, and indefinite, wave. In the field of physics there remain little but the shadows of former realities.

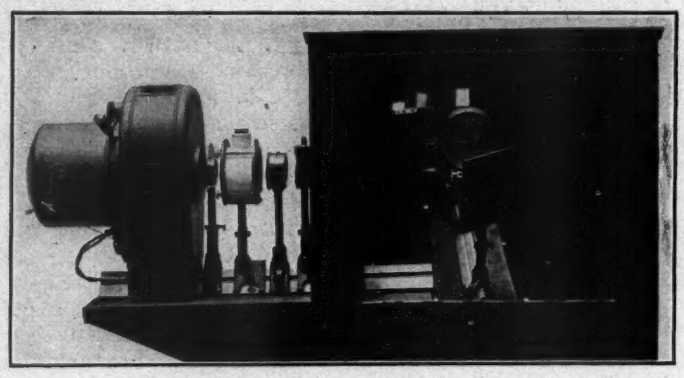
These shadow pictures of reality may be insubstantial, but are they not at least definite and sharply defined? Heisenberg, a leader in the advance guard of theorists, seconded by Bohr, says "No!" We may know, accurately, how large an atom is *or* how fast it is vibrating; but we cannot know both of these things at once. The curious fact is that we learn the exact size of the atom only at the expense of losing sight of its rate of vibrating, and vice versa.

This does not seem so strange when we consider the Schrödinger atom in detail.

The atom consists of a small group of waves whose amplitude diminishes as we pass outward from the center, but never disappears entirely. The atom has, in other words, no definite boundary. For practical purposes, the amplitude at a short distance from the center is so small that it becomes insignificant. Each group of waves, or wave-atom, consists of a number of different lengths and vibration frequencies. By their mutual interference, these waves cancel each other out, with greater completeness as the distance from the center increases. The more rapid the diminution of

amplitude, the more exact the boundary of the atom.

But, as the precision of size of the atom is increased, there is a corresponding decrease in the precision of frequency. This "see-saw" relation therefore makes it possible to find either of these properties to any degree of precision, but not both of them at the same time. This same conspiracy exists between other properties of the atom, such as its position and velocity; nature seems determined that man shall know, accurately, only one thing at a time. This is true to a noticeable extent only when dealing with extremely small bodies, such as the atom and electron but theoretically it applies to larger bodies as well. The very fact that we can see the moon only by reflected light automatically throws into error the measurements we make by that light, since the light itself exerts a pressure, if a small one, on the moon.



—*Radio Engineering*

The Karolus television projector, which makes use of polarized light modulated by a Kerr Cell.

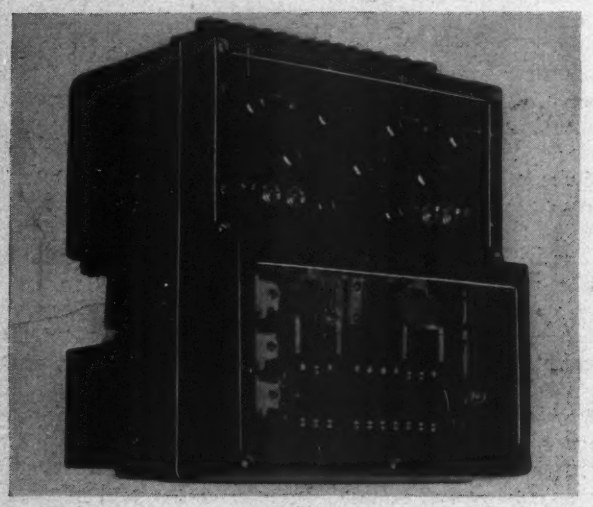
The present-day attitude of physicists toward the reality of matter and energy has led them to believe that matter and energy are made of the same "stuff." Minkowski claims that the true reality is neither matter on the one hand, nor energy on the other, but a kind of blend between the two. Again the emphasis is upon an intangible concept. These new views have helped practical science in many ways. But the possibility remains that the growing unreality of nature may eventually block further investigation.

Electronic Control of Traffic

By Dr. Franklin S. Irby

Condensed from Electronics, issue of September, 1931

The development of electronic (vacuum tube) equipment for use in controlling traffic at street intersections has resulted in four distinct methods: (1) Sound amplifying equipment which amplifies the sound of the passing vehicle; (2) pressure type detectors using an electrostatic timing method; (3) electromagnetic control actuated by the effect of the passing car on a magnetic field; and (4) photo-cell control, actuated by the intersection of a light beam.



—*Electronics*

An electrostatic control unit, which automatically times the reverse of traffic signals, by the use of the charging rate of a condenser.

The first method, or sounding-amplifying principle, makes use of a hollow steel box, buried in the roadbed at either side of an intersection so that it acts as a "drum" or resonator, thus amplifying the sound of the motor wheels as they pass over it. The sound waves thus set up are conducted through a short tube to a microphone which converts them to electrical impulses. These are in turn amplified, and the output of the amplifier used to set in operation the timing mechanism. Ordinarily, the traffic on the main road has continuous right of way, but the passage of a motor over the steel box in the cross road reverses the lights after a short time interval. Pedestrians may obtain the right of way by pressing a button on the control box situated at the street corner. This button, having once been pushed will not reverse the lights again until after a definite time interval, so that tampering with traffic by pedestrians is eliminated.

The pressure type of control makes use of a switch which is operated by the passage of the vehicle over a buried control. This switch operates a relay which begins charging a condenser. This charge takes a definite length of time (several seconds) to become of sufficiently high value to actuate a flashover in a grid-glow tube. When the grid-glow tube reacts, a final relay switches the traffic lights. The only moving parts in such a system are the relays, and the grid-glow tube is specially built for a long life, so that maintenance cost is extremely low. The time interval after which the lights reverse can be controlled by the value of the resistance in series with the condenser, so that flexibility is available to meet different conditions of traffic.

The electro-magnetic type consists of a transformer buried in the surface of the roadbed, and connected to a supply of alternating current. The magnetic field set up about the transformer is interfered with by the passage of the body of the car, so that the current in the secondary changes slightly in value. This change is used to operate the control circuit which reverses the lights. Separate methods are required to obtain the required timing between the passage of the vehicle and the switching of the lights. Vehicles other than those having steel or iron frames will not operate this control system.

The photoelectric cell method automatically registers the passing of the car across a horizontal beam of light. Previous use of a vertical beam has been discontinued due to the dust and grease which collected on the lower member. The output of the photo-cell

operates a grid-glow tube which in turn starts the signal timing device. A special relay is employed which requires the car to remain at rest for a definite time in the path of the light beam before any action will take place. This prevents cars turning from the main highway into the side street from reversing the light when there is no need for it.

Television Turns to Projection

By A. Dinsdale, *Former editor Television Magazine, London*

Condensed from Radio Engineering, issue of September, 1931

The exact status of television in the public mind has been confused by the great amount of publicity which is spread about by opportunists hoping to make a fortune. Those in the industry, especially those in the technical development, realize that there are many major problems to be solved before television becomes a practical reality for the average home. They are unwilling, however, to prophesy when these problems will be solved; it may take years, or the solution may be near at hand.

Progress in television is not now at a standstill. The efforts of the major developers have now been turned toward projecting the televised image upon a large screen. In the recent radio exhibitions held in Chicago and New York, successful demonstrations of large televised images were made to the public. Where formerly it was necessary to view the small image through a large magnifying lens, as in a peep-show, it is now possible for a large audience to view it, much as if in a motion picture theatre.

The problem of projecting televised images has occupied the minds of the leading research organizations for some time. The Bell Laboratories in 1927, by means of an ingeniously contrived neon tube produced an image on a screen two and a half feet square, though no actual projection was utilized. Later, in the Berlin Radio Exposition of 1929, Dr. Karolus achieved true projection by means of an arc modulated by a nicol-prism, Kerr-cell combination. The image in this experiment filled a three foot screen, and the detail was good though the illumination, due to the large losses in the optical system was poor. In 1930 Dr. E. F. W. Alexanderson duplicated this experiment, and improved the illumination by brute-force methods, using a 150 ampere arc to overcome the losses.

An English experimenter built and demonstrated last year a two by five foot screen composed of 2100 tiny flash lamp bulbs, which were actuated by a huge commutator. The picture was produced by the position and degree of illumination of the bulbs. The same experimenter is now working on a method of modulating an arc lamp directly with the television impulses. If this proves successful, the problem of sufficient illumination will have been solved.

The latest method, developed in the United States by U. A. Sanabria, makes it possible to project the picture on a screen six feet square. This system makes use of a disc (for scanning) which has not one spiral of holes, but a triple spiral. The light from each spiral set slightly overlaps that of the other two so that flicker and strip effect are greatly reduced. The illumination obtained is about half of that of a motion picture screen, and the detail is as sharp as most images shown on a home movie projector. A special amplifier, which it is claimed steepens the wavefront of the incoming signal, also contributes to the crispness of the picture.

The Detection and Measurement of Sound

By R. V. Parsons and J. S. Parkinson, *Acoustical Engineers*

Condensed from Heating and Ventilating, October, 1931

Because the machine age has produced new kinds of noise faster than our bodies could develop a protective deafness, it has been necessary to develop practical methods of noise diagnosis and cure. Investigation into the types of noise has revealed that annoyance may be the result of several characteristics; the most familiar of this is excessive loudness. Most people will tolerate sounds until they pass a certain limiting loudness level. The loudest noises, however, are not always the most unpleasant. The frequency, or combination of frequencies (the quality of the sound) often determines the degree of annoyance produced. The screech produced

(*Continued on page 198*)

An acoustical laboratory. Notice the many applications of electricity to the measurement of sound.

—*Heating and Ventilating*

The TECH ENGINEERING NEWS

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EDITORIALS

Depression and the Machine

When the world finds itself in the strangling clutch of unemployment, bitter is the outcry against machinery. From Mahatma Gandhi, visualizing an India reverted to the old-fashioned spinning-wheel, to Count Keyserling, lecturing in Paris on American civilization as the "tragic misconception of the modern epoch, traceable to a failure to recognize that man is essentially spiritual," many an idealist lays the blame for world distress upon The Machine.

From the ranks of education and scientific research the reply to the accusation of "mechanical man" and of unemployment because of new inventions comes with equal vigor. An Oxford don replies that "the average clerk . . . is an infinitely better-behaved and better-informed person than the Athenian who sat spellbound at the tragedies of Aeschylus." The President of Technology replies to the charge that machines throw men out of work by citing reports from industry which show that with the advent of mechanical improvements come also new products to manufacture, hence, the loss is merely temporary. Furthermore, "The idea of devoting four to twelve years of a child's life—of every child's life—to education did not come until the machine had economized labor and multiplied production so that there was a surplus, a margin which has freed the children."

According to a great research executive in the field of electricity, "man is essentially spiritual, but his tokens of value, his media of exchange, call for material —even mechanical devices."

There is no need to blame the scientists. Let us call rather upon an international economist, who, knowing the benefits science has brought, will attempt to regulate man's barter so strategically that future generations will no longer dread Depression and Unemployment.

Vistas

Unconsciously and unthinkingly we are accustomed to saying that if a certain desire or hope could be realized or an end attained, then would our cup be full. A tranquil period of rest and ease, free from the distracting effects of pleasure and obligation, would follow. A loose habit, this, and one to be corrected, for certainly nothing could be farther from the truth. The man who for several years has worked to get into college, discovers upon arriving there that he has not reached the heights but is at the threshold of four years of effort, competition, and activity.

That great English protagonist of reform, the seventh Earl of Shaftesbury, after sixteen years of labor cumulating in the passage of the famous Climbing Boys Act, freed the chimney sweeps from their hazardous and often fatal occupation. He found that the great significance of the bill was not the thing itself but the fact that it was an entering wedge, a single foothold upon which he could base his pleas for greater and more extensive reforms of working conditions in the mining and manufacturing centers.

Accomplishment is not the end, but the beginning.

A task is never really ended; something greater and finer always remains to be done. The important thing is to appreciate the fuller significance of what we do and to go forward.

Relief for Civil Engineers

Employment, which makes the acquisition of a "sheep skin" more than a mere gesture, was, in too many instances this past June, a non-existing climax to the graduating engineer's four years of technical preparation. Among those graduates most seriously affected by the inactivity of business were the civil engineers.

The field of Civil Engineering is already so well covered that the man without exceptional ability or the usual "pull," experiences difficulty in getting himself placed in a position of usefulness as a civil engineer. His only alternative is to devote his attention to another field less developed but at the same time closely related to Civil Engineering.

Sanitary Engineering, which for many years was included in the work of the civil engineer, has gradually diverged from Civil Engineering and is steadily gaining recognition as an independent engineering profession in itself. Questions of such vital import as adequate drainage of our large cities, proper disposal of sewage and industrial wastes, prevention of disease, purification of water supplies, elimination of dust and noise, and installation of lighting and ventilating systems have demanded the attention of the engineers to such an extent as to necessitate their specializing in that type of work.

As a profession, Sanitary Engineering is becoming more and more extensive in its scope as the cities increase their size. But as yet, it covers a field comparatively undeveloped and lacking in man power. Civil Engineers, especially, are becoming aware of this fact and are now turning their attention to this branch of engineering. More concentrated effort in the profession of Sanitary Engineering might well relieve the congestion now ascendant in the ranks of the Civil Engineer.

Language and the Engineer

Often a student who takes a keen delight in scientific or mathematical subjects is heard to bewail the futility of years of language study. Is there any practical value in the acquisition of a foreign language?

The answer is twofold. Purely from their knowledge, the language scholar has a tremendous advantage over others less well-equipped. When the latest works by a foreign master are fresh from the printer, facility in language enables him to peruse them at his pleasure, long before translations are published. In case the book never goes beyond the mother-tongue of the writer, the language student has an evident superiority.

But aside from their direct value, languages have an even higher intrinsic worth. From antiquity, the study of foreign tongues has been held an excellent discipline for the mind. For a true appreciation of his native tongue, one need only study another's. With comprehension of languages, vocabulary is immeasurably richer, expression grows stronger. The engineer, faced as he is with the necessity of putting technical exploits into simple phrases which can be readily understood, needs the discipline of language for his mental gymnastics. He needs the clarity of expression, the dignity of speech given only by a deep understanding of "the gift of tongues."

BENJAMIN FRANKLIN

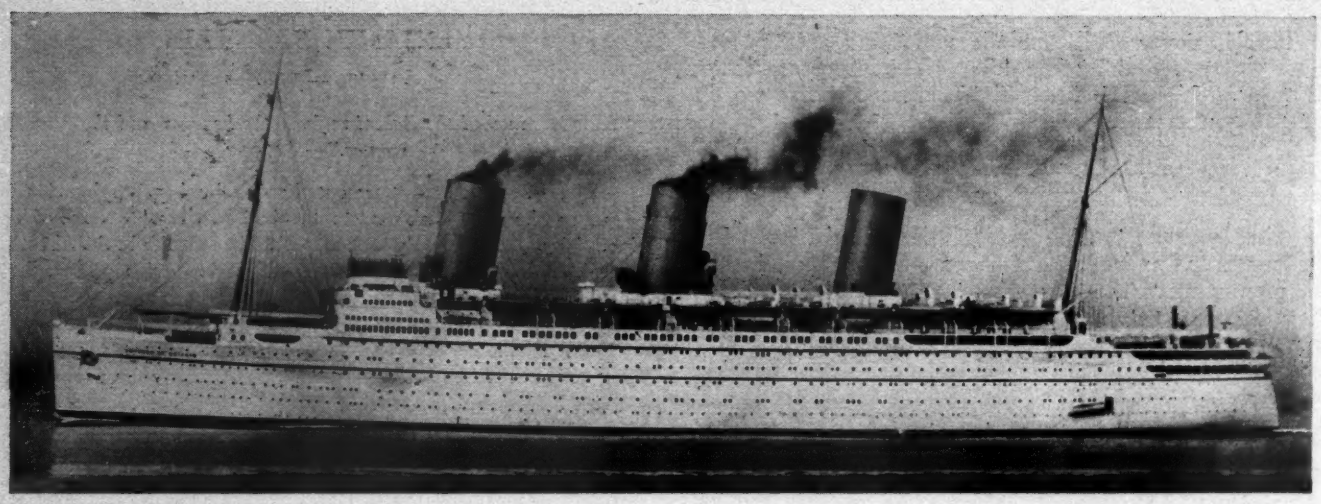
1706 — 1790

"He has snatched the lightning from the heavens and the tyrant's scepter."—TURGOT

The only American represented on Technology's pylons is the Quaker who must rank next to da Vinci for the wide scope of his activities. We can only look into his scientific life in this sketch, ignoring his great work in education, public service, philosophy, and statesmanship, and in helping to guide our country through its early and stormy days. Very early in life Franklin showed interest in things about him and soon developed a taste for reading which lasted throughout his life. His early scientific studies trained his mind, improving his logic and reasoning powers. The wise young man spurned most of the pleasures of his day in favor of the personal discipline which was one of his essential characteristics. He saw that the entire civilized world was passionately interested in electricity and commenced his experiments in 1746. Building his own apparatus, he was able to make the most complicated experiments, thanks to his manual skill and his sturdy common sense. He had only his experiments as the basis for his theories, which he explained in common, everyday words, so that he remained logical and intelligible.

Franklin named the two kinds of electricity positive and negative, expressing them by plus and minus signs. After studying the electrical properties of metallic points, he crowned his theories with success in June, 1752, by performing his famous experiment, in the course of which he might easily have been killed. Flying his kite during a storm, he found that the key attached to the end of the kite string was charged with electricity, proving the identity of lightning with electricity. This, the most brilliant scientific discovery of the century, soon led to his invention of the lightning rod. His discoveries spread quickly over the world. Lightning rods shot up from Boston to Charleston while philosophers and leading thinkers were enthusiastic about the invention. Science had made progress which all could see, appreciate, and utilize. King Louis XV sent his compliments to Franklin in the first letter that a king ever wrote to a candlemaker's son.

Less well known are some of his other scientific activities. He took sea temperatures on his many voyages and made the first real discoveries relative to the Gulf Stream, lectured on the Aurora Borealis to the French Academy of Science, investigated the mystery of toads found enclosed alive in solid stone, proposed daylight saving time, invented bifocal lens spectacles, learned the possibilities of calming water with oil, and made an investigation of Mesmerism. He studied the inventions which were sent to him from all over the world and was a contributor to the expenses of early aeronautic experiments, being a staunch believer in the future of balloons. Franklin held the place that Newton had formerly occupied in the world of science. Because of this lightning rod, many regarded him as an enchanter. He was the most illustrious scholar of his century and his works were translated and read eagerly everywhere. He was sedate and weighty in his personal bearing, and had no striking eloquence, but men instinctively felt his worth and submitted themselves to his wisdom. He presented a modern idea of electricity out of vague clouds of speculation, giving concrete form to hazy abstractions on the subject. The shrewdest politician of the eighteenth century and a perfect diplomat, he was a great patriot. (We recommend "Franklin, The Apostle of Modern Times" by Bernard Fay, Little, Brown and Co., 1929, for a complete picture of this great man.)



—*Marine Review*

The Empress of Britain, driven by turbines, is issuing a definite challenge to the Diesel drive.

THE TRANSATLANTIC LINER—1819-1931

(*Continued from page 189*)

In 1905 a very significant experiment was conducted. Two sister ships, the *Caronia* and *Carmania*, were built, 20,000 ton vessels of 18 knots, the former being a twin screw vessel with quadruple expansion reciprocating engines, and the latter a triple screw ship with steam turbines. The performance of these steamers was carefully watched, and it was found that the steam turbine was better adapted to high powers and speeds than the old piston engine. With the results of this experiment in mind, two splendid and justly famous liners were built in 1907, propelled by turbines and quadruple screws. These were the well known *Mauretania* and the ill-fated *Lusitania*, the largest and fastest vessels produced up to that time, being 762 feet long, of 30,000 tons, and capable of 26 knots. These swift greyhounds reduced the time between New York and Queenstown to less than four and a half days, and for twenty-two years they jointly held the "blue ribbon" of the Atlantic, the *Lusitania* being torpedoed during the World War.

In 1929 the speedy *Mauretania* found herself eclipsed by the *Bremen* and *Europa*, German liners of unusual appearance and performance. Their low funnels, stream-lined hull and superstructure, and bulbous bow gave the impression of speed, which indeed was deserved, for on her maiden voyage, the *Bremen* made an average speed of 27.83 knots, and has broken her record since. Her maximum speed was recorded as 29.5 knots, and it is rumored that both the *Bremen* and *Europa* have never been pushed to the limit, and are capable of 32 knots.

Within the last six years, a new type of engine has found its way into large liners. This is the Diesel engine, for which is claimed fuel economy superior to that of steam. Considerable rivalry between the Diesel engine and steam power has been aroused by the installation of this new engine in a dozen good sized liners, one of the best known being the *Britannic*, nearly 700 feet in length, with a tonnage of 27,000, comparing favorably in size with the large steamships.

Serving well as a challenge to the advance of the Diesel engine, the *Empress of Britain* was placed in service in 1931, a 42,000 ton liner 733 feet in length, with 12 geared steam turbines. This vessel has obtained economies in fuel consumption hitherto unapproached, and her power plant stands as a tribute to the genius of its designer.

In 1933 the world will see the greatest wonder of the seas yet conceived by man. This will be the gigantic Cunard liner *Princess Elizabeth*, 1018 feet long, 115 feet wide, of 73,000 tons. Not only will this be the largest steamship afloat, but the fastest and most luxurious as well. She will be capable of at least 32 knots, making the Atlantic passage in four days. It is estimated that the *Princess Elizabeth* will cost $30,000,000, interior decorating alone costing $2,500,000. Her power plant would produce enough electric current to light a city of 100,000 people. She will have a million dollar gyroscope stabilizer weighing 300 tons, which will make her remarkably steady in the roughest sea. This new liner will carry 5000 passengers. The build-

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ing of the *Princess Elizabeth* will result in an expenditure of $125,000,000 for accomodations in Great Britain and America, a very appreciable blow against the depression and unemployment. This splendid liner will replace the *Mauretania*, which after twenty-four years of faithful service, is rapidly ageing.

No one knows what the next stage of transatlantic liner development will be. There are certain limitations at present. A ship much longer than a thousand feet would be awkward to handle and would draw too much water to enter most harbors. Speeds in excess of 36.5 knots would result in power plants which would not only be expensive to build and operate, but which would be too large for the vessel. The power of a ship's engines increases more rapidly than the speed. For instance, at moderate speeds, the power increases with the seventh power of the speed, while at 35 knots, the power varies as the fifteenth power of the speed. Outside of these and certain other limitations, however, a wide field is open for the development of transatlantic liners, and perhaps progress will modify some of these limitations.

IRON HORSE

(*Continued from page 190*)

From the foregoing it may readily be seen that while it was necessary to carefully consider the motive power units from the standpoint of maximum use of standardized parts throughout the design, it was also necessary to consider these units from the standpoint of their adaptability to different sizes, weights and speeds of trains, as well as to the effect in the future of changes in weights and speeds of trains on these designs. The mechanical and electrical parts of the passenger locomotives are almost entirely interchangeable between themselves and with the mechanical and electrical parts of the freight locomotive. The passenger locomotives are to be built for a safe maximum speed of 90 miles per hour and to develop their continuous rating at 54 miles per hour; the freight locomotives are to be built for a maximum speed of 45 miles per hour and to develop their continuous rating at 27 miles per hour.

Last, but not least, should be mentioned the fact that one of the most important things to consider in a railroad's electrification is a properly worked out and adequate program of the electrification construction work. This program should be so laid out that the electrification will be completed at the time set by the management and that in meeting this date the minimum amount of working time is consumed and that the delivery of material and equipment is properly coordinated with the working schedule, so that the minimum idle investment is reached, and the installation as a whole is made available as nearly as possible at one time. After this program has been laid out carefully a frequent check should be made to see that it is filled and the necessary steps taken to bring up such operations as are lagging behind their schedule. In this program ample time should be inserted for testing of all circuits, equipment and rolling stock, so that on the date set by the management a finished and satisfactorily operating electrification will be turned over to the Operating Department of the railroad for their use.

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ROCHESTER NEW YORK

ENGINEERING DIGEST

(*Continued from page 193*)

by the wheels of an elevated train as it rounds a curve, annoying as it is, is not nearly as loud as many of the other operating noises. The thing which makes it irritating is its extremely high frequency.

A third factor influencing annoyance at noise is psychological in character. Among the hundreds of complaints studied by the New York Noise Abatement Commission, a large percentage dealt with noises which were not particularly irritating in themselves, but which were conceived to be unnecessary or deliberately malicious. Fan noise somewhere in a ventilating system will sometimes upset an owner beyond all reason, whereas he will pay no attention to a nearby electric fan which is making ten times as much noise. One is conceived to be necessary and the other unnecessary.

Most of the factors which govern annoyance are susceptible to fairly exact measurement. Sound energy can be easily measured with a microphone, an amplifier, and a meter to measure the amplitude of the resulting electric vibrations. All accurate sounding measurement devices should provide some means of weighing the results according to frequency in the same manner as the ear, especially if the measurements are to be used to correct annoying conditions. The frequency characteristics of sound may be further investigated by means of electrical filters. Each filter in the circuit is adjusted to pass a certain known band of frequencies. The energy of this band may be determined and the process repeated for the next band, and so on. Such an analysis is often of special value in dealing with some particular source of noise and isolating it from its fellows. The oscillograph will also yield a good deal of information about the frequency characteristics of sound.

Presented with an actual problem, what does the acoustical engineer do with this array of instruments and engineering knowledge? First he learns where the noise is heard, and if possible, where it is heard loudest. He then examines openings and panels in the building structure to determine the path of the sound. The next step is the determination of the source. By ear, or by instruments, he may be able to learn enough of the quality of the sound to discover the origin. Having discovered the source and path of the sound, he must find out why it is annoying, in order to provide the most efficient and effective cure. The elimination of certain frequencies will often effect a cure. Once the source, loudness, and distribution of the sound, together with its frequency and energy characteristics, are known, a cure for the annoyance can almost always be worked out.

PHOTO INTEGRAPH

(*Continued from page 188*)

ground glass give a rough adjustment of the light. Final adjustment is obtained by rotating the plane glass up to seventy degrees about a vertical axis, thereby changing the light in the system up to ten percent by reflecting different amounts of light.

Upon the shutter depend the calibration, accuracy, and linearity of the machine. It is operated by a worm gear drive actuated by a lead screw which runs across the result platen. A pencil rider traces a line on the platen as the crank opens and closes the shutter. The ordinates on the result plot are thus proportional to the opening of the shutter and therefore to the amount of light passing into the second photo-electric cell. This is made to equal the amount of light passing into the first cell by comparison on a galvanometer and therefore the ordinates correspond to the integral of the product of the functions plotted on the two masks.

The electrical circuit utilizes a thermionic tube. The photo-electric cells are arranged in series across a battery, their common point being connected to the grid and the midpoint of the battery to the filament of the thermionic tube. When light passing through the two cells is equal, the potential across the thermionic tube is zero and the galvanometer reads zero. The sensitivity of the method is great.

In operation, the two masks are set in their proper positions, the light through the auxiliary system is adjusted to the scale desired, and the mirror oscillations started, oscillating the first mask with it. With his left hand the operator turns a crank moving the second mask through the range of the variable parameter of the equation, at the same time moving the result platen under the pencil rider. With his right hand he turns a second crank which actuates the shutter, keeps the two light systems equal, and sends the pencil rider across the result platen. The combined motion of the result platen and pencil rider traces out the result curve.

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ATOMIC THEORY - 1931

(*Continued from page 185*)

In return, then, for the surrender of a few unimportant pictures we have a new set of fundamental principles. Before taking up the results it would be well to remark that there are several ways of formulating the new principles. These different methods are not, however, in competition with each other but may, for the purpose of this article, be considered equivalent. The wave mechanics of Schrodinger simply sets down a certain partial differential equation without excuse and gives rules for connecting the symbols which appear in it with the quantities we measure. The matrix mechanics of Heisenberg achieves the same results starting with equations which have the same form as the classical equations of physics. However, the symbols which occur in these equations represent numbers more general than those about which we learn in school. The schoolboy is taught how to count, and his later mathematical training deals mainly with the manipulation of the numbers which occur in the counting process. Only in advanced work is it brought out that other processes can be treated numerically provided we use numbers with fewer restrictions on them than are imposed on the simple numbers. These most general numbers, each composed of a manifold of simple numbers, are called matrices. The classical equations turn out to be true in terms of such matrices. In limiting cases the matrices degenerate to simple numbers and only then is the older physics applicable. Still another formulation: the operator mechanics due to Dirac, emphasizes the fact that the matrices which arise in the theory of atomic physics are always representations of experimental operations leading to numerical results. This permits a more direct attack on physical problems than the straightforward application of the general matrix analysis. In other words, physical intuition is allowed to play its proper important part in the operator mechanics.

It appears, then, that more and more mathematical technique is being required of the physicist. On the other hand, his tools are becoming correspondingly more powerful. The analogous thing is happening on the experimental side. The layman cannot hope to follow the proofs. He must at first depend on criticism within the field itself for assurance that the results are trustworthy. If he wait long enough he will find other proofs—in the application of the results. That there will be applications there can be no doubt, because the main achievement of the new physics is of a most practical type. Whereas formerly we could predict rather well in many cases what would happen, only recently have we learned to calculate and measure at what rate it would happen. We know, for example, a great deal about the energy levels between which an electronic system could jump. Now we know something about the probability of the process.

Furthermore, it has been shown that the individual events out of which a process is composed happen at random. That is, there is at every moment a constant probability that a certain event will take place and we cannot say that at a definite instant the thing must happen.

In other words, we do not pretend to have an exact description of our systems. The reason for the indeterminacy is the fact that our tools are necessarily finite in size and when we try to measure the minute

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dimensions of atomic systems with them, the reactions they produce on the system are by no means negligible. Their influence cannot be determined without another experiment; but, since this in turn will introduce a further interaction, we can get no nearer to perfect precision.

As we see it now this limitation is the essence and explanation of the whole quantum theory. It has not so far been possible to give a *complete* proof that this Principle of Indetermination is equivalent to the wave equation, for example, but surely the connection is there. In this sense we say that the physicist understands the new mechanics.

Just now the theory is at a standstill with regard to the relation between relativity and quantum mechanics. It will be necessary to bring the two together in order to study the nucleus of the atom which is the next great field for research. Here non-relativistic treatments are worthless. On the other hand, relativistic treatments are extremely difficult, especially because we have no fundamental experiment to guide us in this region.

This is not to be taken to mean that no good experiments are being performed with the nucleus and its radiations. As a matter of fact, fascinating results are being obtained and interesting calculations are showing that the new physics can go much farther than the old. But the key to the mystery of the nucleus is still hidden. It is most exciting as the new journals come out, to look for contributions in this field. When the strike is made another period of tremendous activity will begin.

FIRE ALARM

(*Continued from page 187*)

The writer has repeatedly seen such efficient handling of fire alarms that apparatus was actually at work on the fire before the sounder of the alarm had had time to realize that the signal had been fully transmitted. As science offers new devices and better means for utilizing the old ones, the fire alarm engineer will apply both means and methods to the speeding of the signal, and to the greater accuracy and dependability of the call. Each second in fire fighting is important and the task of science in this connection is to make each second count.

Standard structural steel can now be used for fabricating rugged fireproof floors in building construction work. The new design permits the floor to be laid in conjunction with the erection of the building framework by the steel contractor. Channel or I-beams, either standard or light weight, are placed closely together to form the floor section, so that the adjacent flanges interlock. Connection between the flanges is made possible by the use of bolts, rivets or welding. The high strength of a floor so constructed makes it possible to space the supporting beams further apart, with a resultant decrease in the framework cost.

The Managing Board takes pleasure in announcing the following staff elections: Robert Ebenbach '34 to position of Assistant Circulation Manager; E. D. Lucas '34 to the Editorial Staff.

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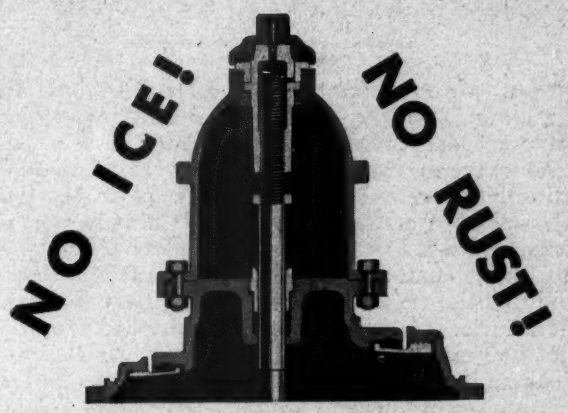

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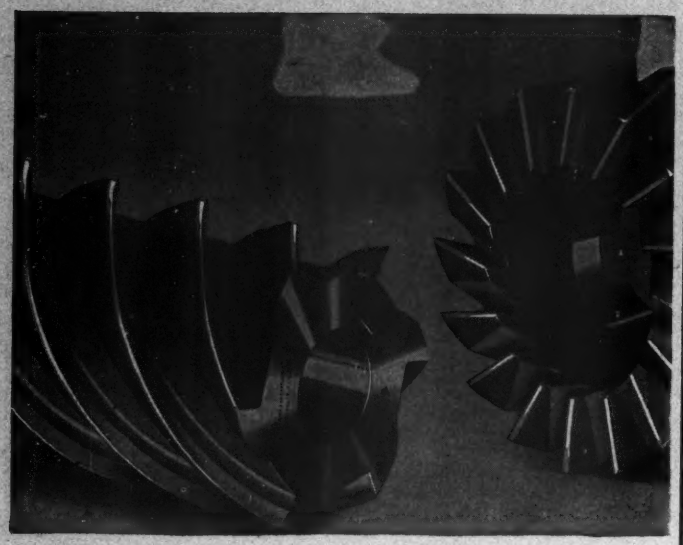

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PREVIEW

"THE Manchurian Triangle—Its Physical Background," written by Professor F. K. Morris of the Geology Department, comes just at a time when the strife between China and Japan over Manchuria is attracting world-wide attention. Professor Morris, besides spending considerable time in China in Geological Research work, has carefully followed the trend of affairs in China, Japan and Russia and has made a thorough study of the respective interests of these countries in Manchuria. It is therefore with a great deal of authority that he presents the real facts concerning the present dilemma in the Orient and gives the reader a better understanding of the causes of the war between China and Japan.

"THE Physical Universe as it is known today is contained within a spherical region having the earth as its center and a radius of two or three hundred million light years—or something like 10^{21} miles." Thus does Dr. Robert H. Baker, Research Associate in Astronomy at Harvard University, at the very outset of "Modern Conceptions of the Universe" acquaint us with the immensity of the world system as at present conceived of by astronomers. Dr. Baker then proceeds to picture the universe as consisting of millions of celestial bodies spaced at inconceivable distances from the earth and stabilized into a system by gravitation and the motions of the bodies. The problems which confront the astronomer as he attempts to comprehend this great system have their special appeal for the layman as well.

IN "Saints of Chemistry," Professor H. M. Smith, of the Chemistry Department, presents a few of the interesting details attending the collection of the group of famous chemists' pictures which grace the walls of the first and second floors of Building 4. These pictures continue to be a source of interest throughout the student's four years in Tech and for this reason it is worth while knowing how they originated there. Attention is called particularly to the painting entitled, "The Synthesis of Alizarin" which two years ago found its way into the Chemistry Department more or less as an outcast. Since then, Professor Smith has made an interesting search to determine just how it came into the possession of the Institute, but as yet has met with little success in his quest.

TODAY when a fire department responds to the call of a fire alarm, likely as not it will find the fire extinguished when it reaches the spot. Automatic sprinkler systems are described in "Automatic Fire Protection" and the principle of the sprinkler head, familiar in Technology's halls and laboratories, described. Some facts about large fires, conflagration hazards and the marked effect automatic protection has had upon them are included. A surprising amount of research and engineering has gone into these systems since their inception, some fifty years ago.

ITEMS of engineering interest such as the further development of mercury vapor power, the future of the autogiro, and the latest development in the carburizing of steel with gas appear in this month's "Engineering Digest." This new feature now appearing for the second time is especially designed for those who, because of lack of time, do not have the opportunity of reading these articles in their original length.

The TECH ENGINEERING NEWS

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